M E M O R A N D U M

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From: Belinda G. Hargrove
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Date: September 19, 2002

Subject: **Final Capacity Results, Preferred Noise Alternative**

TransSolutions has completed a capacity analysis of the proposed noise alternative for Louisville International Airport. The analysis was conducted using the FAA Airport and Airspace Simulation Model, SIMMOD. Simulations were conducted for both visual and instrument meteorological conditions, and for operations on Runways 17L and 17R (south-flow) and on Runways 35R and 35L (north-flow). Details of the analysis approach and findings are provided in the remainder of this memo.

Assumptions. An assumptions memo was presented to you detailing the airfield, airspace, and traffic demand modeling assumptions. The assumptions that are specific to the preferred alternative are restated for clarity.

- The proposed alternative includes a 1000 ft. extension on Runway 17R/35L (500 ft. on each end). Each runway end will have a displaced threshold of 500 feet, such that the touchdown points remain unchanged from today's operations.

- Turbojets use initial departure headings following the preferred noise abatement alternative flight tracks:
  - Departures from 17R: westbound aircraft maintain a 15-degree divergence (200 degrees) and eastbound aircraft maintain runway heading.
  - Departures on 35L: maintain runway heading for one nmi, then a 15-degree divergence (330 degrees).
  - Departures on 17L and 35R: no change for departure tracks from the SDF Master Plan Update.

- The proposed alternative includes a 15-degree offset for Runway 17R approach procedures, maintaining a 15-degree intercept followed by a turn onto the runway heading at one nmi. from the runway end. The 17R final approach is extended to, as a minimum, the final approach fix (i.e., aircraft from the south, east, or west cannot use a short final, similar to what often now occurs during visual approaches).

- To represent reduced exceptions to contraflow, half the north-flow departures during the nighttime arrival peak (23:00 – 02:00) were moved to the nighttime departure peak (03:00 – 05:00) in south-flow. Similarly, half the south-flow arrivals during the nighttime departure peak were moved to the nighttime arrival peak in north-flow.

- North-flow preference is given to morning operations, 9:30 am - 12:30 pm.

- The runway usage in SIMMOD is based on the FAR Part 150 Noise Compatibility Study. The runway usage tables are attached in the Appendix.

The analysis was conducted using two traffic demand scenarios from the Master Plan Update

- 656 daily operations, representing an average day, peak-month for 2000
- 826 daily operations, representing an average day, peak-month forecast for 2010.

Airfield Capacity Analysis. When using a simulation model, the primary measures of airfield/airspace capacity are:

- Arrival airspace delay
- Departure taxi-out delay (includes departure queue delay).

The results presented here focus on airfield and departure queue delay, not the ramp/gate operations.

Delay is measured as the difference in the amount of time an aircraft actually lands or departs the runway and the time it would have used the runway if it were able to move unimpeded throughout the airfield/airspace system. For example, if there is only one aircraft taxiing out to depart and it obtains immediate departure clearance, the aircraft would have no delay (or 0.0 minutes delay).

The majority of the arrival delay occurs in the airspace as aircraft must maintain separations and are merged into final approach. The majority of the departure delay occurs on the airfield because aircraft are cleared for takeoff only when proper separation has been achieved. Thus, fewer departure headings or flighttracks will generally result in higher departure taxi-out delays. At Louisville, departure delay is also influenced by aircraft going in the same direction, but departing on opposite runways. For example, when an eastbound aircraft departs the west runway, additional time is required before an eastbound departure can depart the east runway so that the two aircraft will achieve the necessary separation in the airspace.

These delay statistics were evaluated for the entire 24-hour traffic demand and for nighttime operations (10:00 P.M. to 7:00 A.M.), as presented in the following four tables. The Master Plan Update (MPU) Airfield Capacity Analysis results are included in the tables to show a comparison between current operations and the preferred alternative.

Table 1. South-Flow (Runways 17R/17L) Visual Meteorological Conditions Average Delays (in minutes)

Daily Traffic	24-Hour Daily Average		Nighttime Operations Only	
	Average Arrival Airspace Delay	Departure Taxi-Out Delay	Average Arrival Airspace Delay	Departure Taxi-Out Delay
Preferred Noise Alternative				
656	0.69	1.33	0.93	2.09
826	1.18	1.63	1.61	2.39
Master Plan Update				
656	0.79	0.97	0.99	1.34
826	0.95	1.23	1.39	1.87

Table 2. North-Flow (Runways 35L/35R) Visual Meteorological Conditions Average Delays (in minutes)

Daily Traffic	24-Hour Daily Average		Nighttime Operations Only	
	Average Arrival Airspace Delay	Departure Taxi-Out Delay	Average Arrival Airspace Delay	Departure Taxi-Out Delay
Preferred Noise Alternative				
656	0.57	1.22	0.81	2.25
826	0.93	2.02	1.44	4.22
Master Plan Update				
656	0.43	1.05	0.52	1.70
826	0.56	1.12	0.72	1.94

Table 3. South-Flow (Runways 17R/17L) Instrument Meteorological Conditions Average Delays (in minutes)

Daily Traffic	24-Hour Daily Average		Nighttime Operations Only	
	Average Arrival Airspace Delay	Departure Taxi-Out Delay	Average Arrival Airspace Delay	Departure Taxi-Out Delay
Preferred Noise Alternative				
656	1.09	3.56	1.69	6.13
826	1.98	4.41	3.15	7.29
Master Plan Update				
656	1.22	1.84	1.76	3.18
826	1.58	2.83	2.63	5.27

Table 4. North-Flow (Runways 35L/35R) Instrument Meteorological Conditions Average Delays (in minutes)

Daily Traffic	24-Hour Daily Average		Nighttime Operations Only	
	Average Arrival Airspace Delay	Departure Taxi-Out Delay	Average Arrival Airspace Delay	Departure Taxi-Out Delay
Preferred Noise Alternative				
656	0.87	3.75	1.41	8.11
826	1.76	5.29	3.26	11.90
Master Plan Update				
656	0.58	3.07	0.82	6.20
826	0.81	3.18	1.20	6.50

Finally, an average annualized delay per flight was calculated using the historical wind and weather information along with the simulated delays. Tabulated by Leigh Fisher Associates for the Part 150 Study, the Surface Airways Hourly Data (TD-1440) for January 1, 1990 through December 31, 1999 showed that 78% of the daytime operations occur in south-flow visual conditions, while 14.5% occur in north-flow visual conditions; only 7% of daytime operations occur in instrument conditions. For nighttime operations, 86.7% of the arrivals land to the north, while 90.7% of the departures operate to the south. Combining these wind/weather occurrences with the average delays, the average annualized delays per operation are presented in Table 5 below.

Table 5. Average Annualized Delays (in minutes) for Preferred Noise Alternative

Daily Traffic	Daytime Operations Only*		Nighttime Operations Only	
	Average Arrival Airspace Delay	Departure Taxi-Out Delay	Average Arrival Airspace Delay	Departure Taxi-Out Delay
656	0.52	0.81	0.87	2.40
826	0.87	1.09	1.59	2.92

* Note that this table provides information for daytime only (not 24-hour average, as in the previous tables).

Generally, average arrival airspace delays less than 3 to 4 minutes are considered to be acceptable, while departure taxi-out delays often reach an average 6 to 8 minutes before one considers the standard to be exceeded. Although the preferred noise alternative delays are generally higher than the MPU delays, it is necessary to measure them against those standards to determine whether they are acceptable.

Departure delays for the preferred noise alternative during nighttime IMC are already quite high and become unacceptable in the future schedule. The north-flow departure delays are higher than the south-flow departure delays due to the runway usage being

more balanced in south-flow operations. In the MPU, the north-flow nighttime departure runway usage at the lower demand level was more evenly split between the two runways but the preferred noise alternative has 75% of the nighttime departures using Runway 35L. However, as the traffic demand increases, both the MPU and the preferred noise alternative have a similar runway usage: the MPU uses Runway 35L for 65% of the nighttime departures while the preferred noise alternative uses Runway 35L for 69% of the nighttime departures. With very little difference in the runway usage, the increased delays must be caused by the change in the flighttracks or departure headings. However, one should note that while the nighttime north-flow departure delays in instrument conditions are at unacceptable levels, these weather conditions occur less than 1% of the year.

In south-flow, the arrival runway preference is being moved from Runway 17L in the MPU to Runway 17R with the preferred noise alternative. Regardless, the split between the two runways is still quite similar, with 80-90% of the arrivals on the primary runway. Meanwhile, the departure runway usage is quite similar for both the MPU and the preferred noise alternative. Thus, once again, the increased departure delays must be attributed to the airspace changes with only one departure heading off each runway.

Hourly delays were also considered because of the time-critical nature of the overnight cargo shipments. Figures 1 through 4 depict hourly average delays for visual conditions. The most critical delays to be considered occur during the peak hours: 23:00 to 02:00 for arrivals and 03:00 to 05:00 for departures. During VMC, hourly arrival delays are acceptable throughout the day in north and south-flow for both demand levels. Hourly departure delays during VMC remain at or under the maximum acceptable delay of 8 minutes.

Figure 1. Hourly Average Arrival Airspace Delays South-Flow / Runways 17L/17R (in minutes)

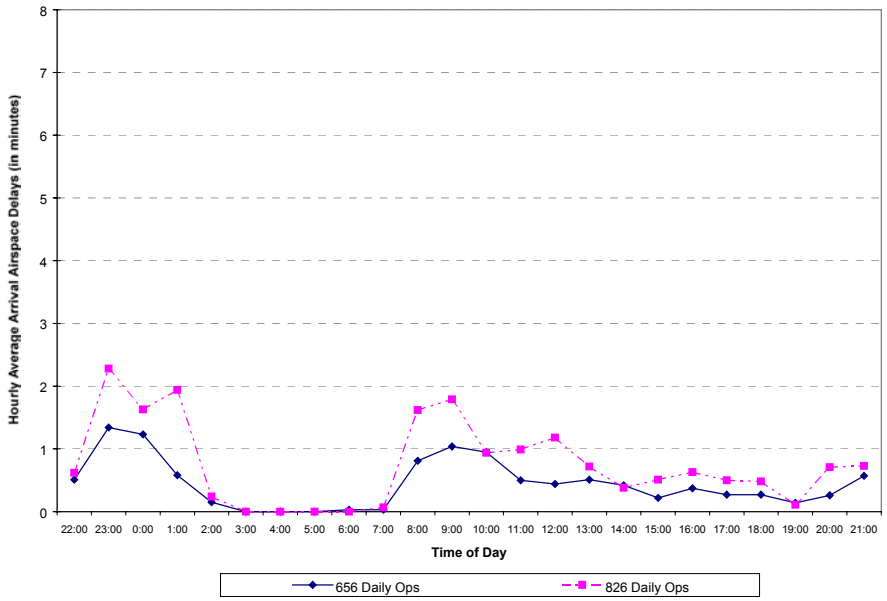


Figure 2. Hourly Average Departure Taxi-Out Delays

South-Flow / Runways 17L/17R (in minutes)

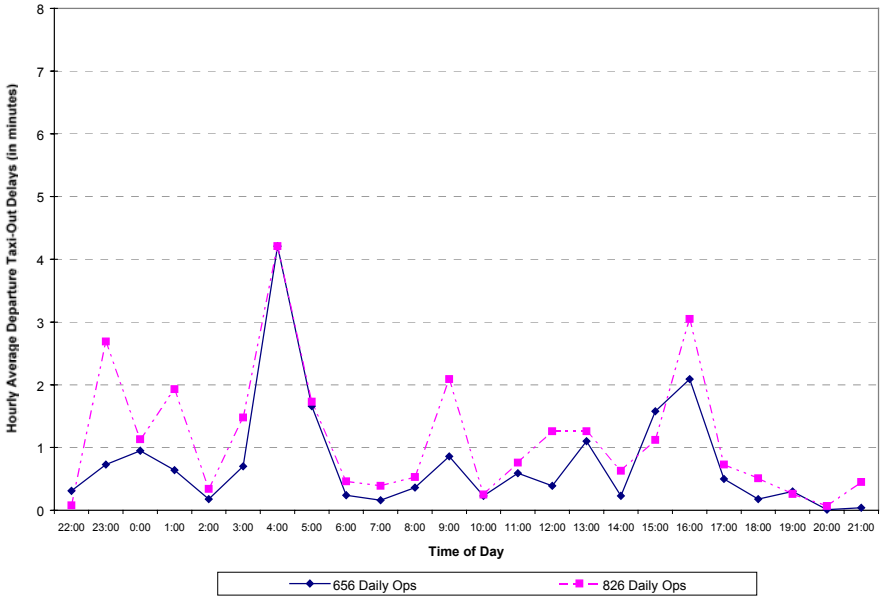


Figure 3. Hourly Average Arrival Airspace Delays
North-Flow / Runways 35L/35R (in minutes)

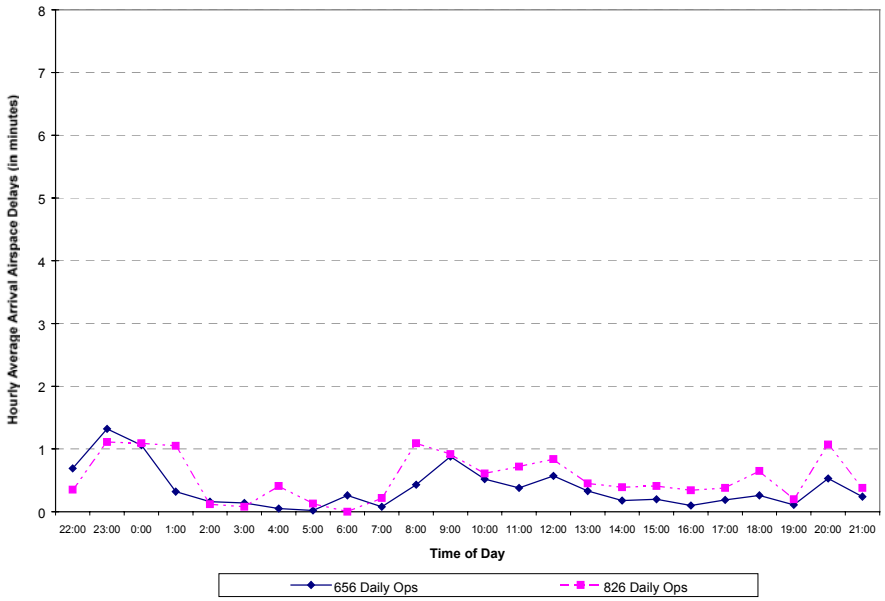
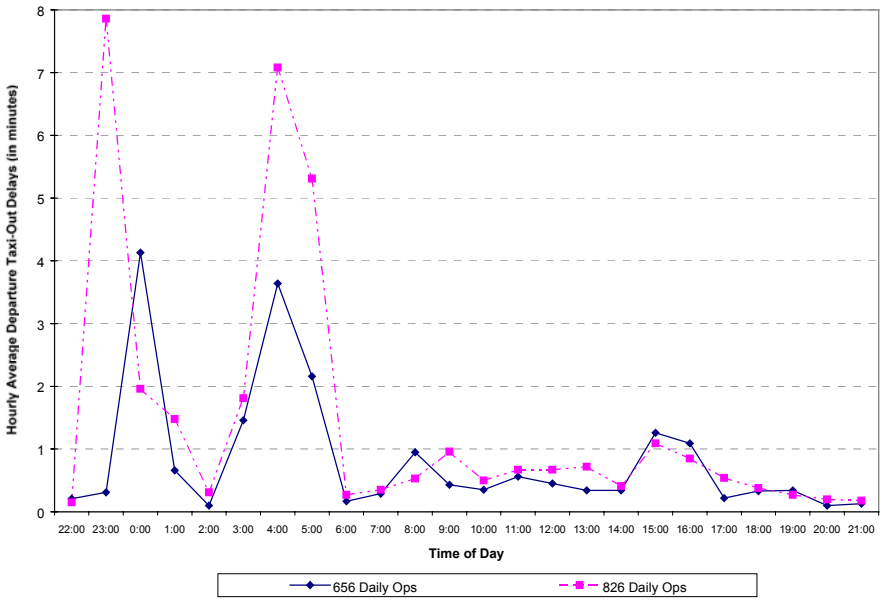


Figure 4. Hourly Average Departure Taxi-Out Delays

North-Flow / Runways 35L/35R (in minutes)



Note that there are only two aircraft departing between 23:00-00:00 in the future schedule that experience an average delay of nearly 8 minutes.

In addition to the overall airfield capacity, TransSolutions has analyzed the average taxi times for general aviation (GA) aircraft parking at the GA ramp on the east side of the airfield. In the past, GA aircraft have primarily used the east runway (17L/35R) due to its close proximity to the parking area. In the noise abatement preferred alternative, GA aircraft arrive mostly to Runway 35R, but depart from Runway 35L during north-flow; the average taxi time, excluding any delays, is 4 minutes for GA arrivals and 11 minutes for GA departures. This departure taxi time is 4 minutes higher than that experienced in the MPU scenario. During south-flow, GA arrivals are assigned to Runway 17R and departures are assigned mostly to 17L; the average taxi time, excluding any delays, is 8 minutes for GA arrivals and 5 minutes for GA departures. This arrival taxi time is 2 minutes higher than that experienced in the MPU scenario.

Finally, delay costs were calculated for both the MPU and preferred noise alternatives. Direct aircraft operating costs for the fleet mix operating at Louisville International were calculated for the 2000 base year. Direct operating costs are approximately $1878/hour for 2000 and $2007/hour for the 2010 fleet mix, based on information gathered from various sources including the International Civil Aviation Organization (ICAO) and the Air Transport Association. A summary of the annual delay costs is presented below in Table 6. All costs are stated in year 2000 dollars, without any adjustment for inflation or Consumer Price Index.

Table 6. Average Annualized Delay Costs (in Year 2000 dollars)

Daily Traffic Counts	656 Daily Operations	826 Daily Operations
Direct Operating Costs	$1878/hour	$2007/hour
Current Operating Conditions (MPU Scenario)	$4.3M	$7.0M
Preferred Noise Alternative	$6.4M	$11.7M
Additional Delay Costs Due to Preferred Noise Alternative	$2.1M	$4.7M

While the proposed noise alternative does result in an increased cost, it is important to recognize that there are delay costs being incurred by the operators at Louisville under today's operating environment. The noise alternative increases delay costs by nearly 50% at 656 daily operations.

Conclusions. Due to the time-critical nature of the overnight cargo industry, the peak hour delays for all weather conditions must be closely considered. The Part 150 Study Proposed Alternative provides for acceptable arrival and departure delay in both IMC and VMC under the 2000 demand. However, for the 2010 schedule, with approximately 336 nighttime operations on a peak day, the departure delays during nighttime IMC are unacceptable. However, with only 7% of the annual operations occurring in IMC at Louisville, the nighttime north-flow IMC occurrences are less than 1%. Thus, these excessive delays will only occur approximately 21 hours per year.

Comparing these results against those given in the Master Plan Update Study, conducted in June 2000, the statistics reported herein show higher delays. The increased delays are mostly due to the limitations on flighttrack headings, since the split of runway use has not changed that much from the MPU-simulated operations to the preferred noise alternative. Requiring all jet departures to use the same heading lengthens the amount of time between consecutive departures in order to assure the appropriate separation is achieved.

If the carriers are willing to accept over 7 minutes of delay per departure operation during the 25 days per year while in instrument conditions, then the noise alternative can be operated through 2010. However, one should be aware that with an average of 7.3 minutes per operation (2010 south-flow nighttime departures in instrument conditions), over 10% of the departures have at least 15 minutes of delay. One method to reduce these excessive delays is to more evenly balance the runway usage during peak periods –

however, one must recognize that a different runway usage will change the noise contours.

Recommendations. The Part 150 Study Proposed Alternative appears to be operationally viable under the current demand. However, as peak demand levels approach the 2010 forecast of 63 departures per hour, delays during IMC become unacceptable according to the given standards. One option that could be used to reduce delays is to balance runway allocation, more equitably distributing arrivals and departures during peak nighttime hours as traffic increases.

Appendix.

Table A1. South Flow Runway Usage Year 2000 Schedule

SIMMOD Runway Use

DAYTIME ARRIVAL				
	Num Ops	17L	17R	TOTAL
UPS	21	0.52	0.48	1.00
Jets	114	0.05	0.95	1.00
Turboprop	7	0.14	0.86	1.00
Piston	41	0.00	1.00	1.00
Military	11	0.00	1.00	1.00
TOTAL	194	0.09	0.91	1.00

NIGHTTIME ARRIVAL				
	Num Ops	17L	17R	TOTAL
UPS	107	0.44	0.56	1.00
Jets	17	0.18	0.82	1.00
Turboprop	0	0.00	0.00	1.00
Piston	6	0.00	1.00	1.00
Military	0	0.00	0.00	0.00
TOTAL	130	0.38	0.62	1.00

DAYTIME DEPARTURE				
	Num Ops	17L	17R	TOTAL
UPS	38	0.21	0.79	1.00
Jets	108	0.62	0.38	1.00
Turboprop	7	0.71	0.29	1.00
Piston	31	0.94	0.06	1.00
Military	11	0.64	0.36	1.00
TOTAL	195	0.60	0.40	1.00

NIGHTTIME DEPARTURE				
	Num Ops	17L	17R	TOTAL
UPS	90	0.40	0.60	1.00
Jets	29	0.76	0.24	1.00
Turboprop	0	0.00	0.00	1.00
Piston	22	0.77	0.23	1.00
Military	0	0.00	0.00	0.00
TOTAL	141	0.53	0.47	1.00

Part 150 Study Runway Use

DAYTIME ARRIVAL			
	17L	17R	TOTAL
UPS	0.57	0.43	1.00
Jets	0.05	0.95	1.00
Turboprop	0.05	0.95	1.00
Piston	0.00	1.00	1.00
Military	0.00	1.00	1.00
TOTAL	0.11	0.89	1.00

NIGHTTIME ARRIVAL			
	17L	17R	TOTAL
UPS	0.44	0.56	1.00
Jets	0.20	0.80	1.00
Turboprop	0.00	1.00	1.00
Piston	0.00	1.00	1.00
Military	0.00	1.00	1.00
TOTAL	0.17	0.83	1.00

DAYTIME DEPARTURE			
	17L	17R	TOTAL
UPS	0.24	0.76	1.00
Jets	0.62	0.38	1.00
Turboprop	0.81	0.19	1.00
Piston	0.92	0.08	1.00
Military	1.00	0.00	1.00
TOTAL	0.65	0.35	1.00

NIGHTTIME DEPARTURE			
	17L	17R	TOTAL
UPS	0.40	0.60	1.00
Jets	0.70	0.30	1.00
Turboprop	0.00	0.00	0.00
Piston	1.00	0.00	1.00
Military	0.00	0.00	0.00
TOTAL	0.55	0.45	1.00

Table A2. North Flow Runway Usage Year 2000 Schedule

SIMMOD Runway Use

DAYTIME ARRIVAL				
	Num Ops	35L	35R	TOTAL
UPS	21	0.24	0.76	1.00
Jets	114	0.24	0.76	1.00
Turboprop	7	0.14	0.86	1.00
Piston	41	0.27	0.73	1.00
Military	11	0.00	1.00	1.00
TOTAL	194	0.23	0.77	1.00

NIGHTTIME ARRIVAL				
	Num Ops	35L	35R	TOTAL
UPS	107	0.67	0.33	1.00
Jets	21	0.34	0.66	1.00
Turboprop	0	0.00	0.00	1.00
Piston	10	0.10	0.89	1.00
Military	0	0.10	0.90	0.00
TOTAL	138	0.58	0.42	1.00

DAYTIME DEPARTURE				
	Num Ops	35L	35R	TOTAL
UPS	38	0.63	0.37	1.00
Jets	109	0.82	0.18	1.00
Turboprop	7	1.00	0.00	1.00
Piston	31	0.97	0.03	1.00
Military	11	0.64	0.36	1.00
TOTAL	196	0.80	0.20	1.00

NIGHTTIME DEPARTURE				
	Num Ops	35L	35R	TOTAL
UPS	90	0.68	0.32	1.00
Jets	21	0.86	0.14	1.00
Turboprop	0	0.00	0.00	1.00
Piston	13	1.00	0.00	1.00
Military	0	0.00	0.00	0.00
TOTAL	124	0.74	0.26	1.00

Part 150 Study Runway Use

DAYTIME ARRIVAL			
	35L	35R	TOTAL
UPS	0.27	0.73	1.00
Jets	0.18	0.82	1.00
Turboprop	0.10	0.90	1.00
Piston	0.40	0.60	1.00
Military	0.00	1.00	1.00
TOTAL	0.20	0.80	1.00

NIGHTTIME ARRIVAL			
	35L	35R	TOTAL
UPS	0.65	0.35	1.00
Jets	0.50	0.50	1.00
Turboprop	0.00	1.00	1.00
Piston	0.00	1.00	1.00
Military	1.00	0.00	1.00
TOTAL	0.60	0.40	1.00

DAYTIME DEPARTURE			
	35L	35R	TOTAL
UPS	0.63	0.37	1.00
Jets	0.82	0.18	1.00
Turboprop	1.00	0.00	1.00
Piston	1.00	0.00	1.00
Military	0.00	1.00	1.00
TOTAL	0.77	0.23	1.00

NIGHTTIME DEPARTURE			
	35L	35R	TOTAL
UPS	0.63	0.37	1.00
Jets	1.00	0.00	1.00
Turboprop	0.00	0.00	0.00
Piston	1.00	0.00	1.00
Military	0.00	0.00	0.00
TOTAL	0.75	0.25	1.00

Table A3. South Flow Runway Usage Year 2010 Schedule

SIMMOD Runway Use

DAYTIME ARRIVAL				
	Num Ops	17L	17R	TOTAL
UPS	38	0.42	0.58	1.00
Jets	147	0.02	0.98	1.00
Turboprop	7	0.00	1.00	1.00
Piston	41	0.07	0.93	1.00
Military	11	0.00	1.00	1.00
TOTAL	243	0.09	0.91	1.00

NIGHTTIME ARRIVAL				
	Num Ops	17L	17R	TOTAL
UPS	126	0.48	0.52	1.00
Jets	24	0.12	0.88	1.00
Turboprop	0	0.00	0.00	1.00
Piston	12	0.00	1.00	1.00
Military	0	0.00	0.00	0.00
TOTAL	163	0.39	0.61	1.00

DAYTIME DEPARTURE				
	Num Ops	17L	17R	TOTAL
UPS	50	0.26	0.74	1.00
Jets	148	0.64	0.36	1.00
Turboprop	7	0.43	0.57	1.00
Piston	30	0.93	0.07	1.00
Military	11	0.64	0.36	1.00
TOTAL	246	0.59	0.41	1.00

NIGHTTIME DEPARTURE				
	Num Ops	17L	17R	TOTAL
UPS	116	0.47	0.53	1.00
Jets	31	0.65	0.35	1.00
Turboprop	0	0.00	0.00	1.00
Piston	30	0.77	0.23	1.00
Military	0	0.00	0.00	0.00
TOTAL	177	0.55	0.45	1.00

Part 150 Study Runway Use

DAYTIME ARRIVAL			
	17L	17R	TOTAL
UPS	0.57	0.43	1.00
Jets	0.05	0.95	1.00
Turboprop	0.05	0.95	1.00
Piston	0.00	1.00	1.00
Military	0.00	1.00	1.00
TOTAL	0.11	0.89	1.00

NIGHTTIME ARRIVAL			
	17L	17R	TOTAL
UPS	0.44	0.56	1.00
Jets	0.20	0.80	1.00
Turboprop	0.00	1.00	1.00
Piston	0.00	1.00	1.00
Military	0.00	1.00	1.00
TOTAL	0.17	0.83	1.00

DAYTIME DEPARTURE			
	17L	17R	TOTAL
UPS	0.24	0.76	1.00
Jets	0.62	0.38	1.00
Turboprop	0.81	0.19	1.00
Piston	0.92	0.08	1.00
Military	1.00	0.00	1.00
TOTAL	0.65	0.35	1.00

NIGHTTIME DEPARTURE			
	17L	17R	TOTAL
UPS	0.40	0.60	1.00
Jets	0.70	0.30	1.00
Turboprop	0.00	0.00	0.00
Piston	1.00	0.00	1.00
Military	0.00	0.00	0.00
TOTAL	0.55	0.45	1.00

Table A4. North Flow Runway Usage Year 2010 Schedule

SIMMOD Runway Use

DAYTIME ARRIVAL				
	Num Ops	35L	35R	TOTAL
UPS	38	0.47	0.53	1.00
Jets	148	0.16	0.84	1.00
Turboprop	7	0.14	0.86	1.00
Piston	41	0.12	0.88	1.00
Military	11	0.18	0.82	1.00
TOTAL	244	0.20	0.80	1.00

NIGHTTIME ARRIVAL				
	Num Ops	35L	35R	TOTAL
UPS	130	0.65	0.35	1.00
Jets	31	0.60	0.40	1.00
Turboprop	0	0.00	0.00	1.00
Piston	15	0.00	1.00	1.00
Military	0	0.00	0.00	0.00
TOTAL	176	0.59	0.41	1.00

DAYTIME DEPARTURE				
	Num Ops	35L	35R	TOTAL
UPS	50	0.60	0.40	1.00
Jets	149	0.81	0.19	1.00
Turboprop	7	0.71	0.29	1.00
Piston	30	1.00	0.00	1.00
Military	11	0.45	0.55	1.00
TOTAL	247	0.77	0.23	1.00

NIGHTTIME DEPARTURE				
	Num Ops	35L	35R	TOTAL
UPS	116	0.60	0.40	1.00
Jets	22	0.91	0.09	1.00
Turboprop	0	0.00	0.00	1.00
Piston	18	0.94	0.06	1.00
Military	0	0.00	0.00	0.00
TOTAL	156	0.69	0.31	1.00

Part 150 Study Runway Use

DAYTIME ARRIVAL			
	35L	35R	TOTAL
UPS	0.27	0.73	1.00
Jets	0.18	0.82	1.00
Turboprop	0.10	0.90	1.00
Piston	0.40	0.60	1.00
Military	0.00	1.00	1.00
TOTAL	0.20	0.80	1.00

NIGHTTIME ARRIVAL			
	35L	35R	TOTAL
UPS	0.65	0.35	1.00
Jets	0.50	0.50	1.00
Turboprop	0.00	1.00	1.00
Piston	0.00	1.00	1.00
Military	1.00	0.00	1.00
TOTAL	0.60	0.40	1.00

DAYTIME DEPARTURE			
	35L	35R	TOTAL
UPS	0.63	0.37	1.00
Jets	0.82	0.18	1.00
Turboprop	1.00	0.00	1.00
Piston	1.00	0.00	1.00
Military	0.00	1.00	1.00
TOTAL	0.77	0.23	1.00

NIGHTTIME DEPARTURE			
	35L	35R	TOTAL
UPS	0.63	0.37	1.00
Jets	1.00	0.00	1.00
Turboprop	0.00	0.00	0.00
Piston	1.00	0.00	1.00
Military	0.00	0.00	0.00
TOTAL	0.75	0.25	1.00